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Estimating Yield Impacts of Treasury Demand and Supply Changes*

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Abstract

We develop a rich demand system framework to quantify the yield effects of shifts in U.S. Treasury supply and demand. Our model captures time-varying holdings shares and estimates sectoral demand elasticities using instrumental variables. We find that the Treasury market has become increasingly price-sensitive over time, driven by the declining participation of less price-sensitive foreign official investors and the rising role of more price-sensitive hedge funds and other private investors. A $100 billion increase in Treasury supply currently raises five-year yields by approximately 3 basis points. We validate the model by showing that the shifts in investor base explain a significant portion of historical yield changes. Our framework provides a flexible tool for policy analysis and counterfactual scenarios, including the yield effects of foreign official investor sales and Federal Reserve balance sheet policies.

JEL Codes: E43, E52, G11, G12
Keywords: Treasury markets, demand elasticity, asset pricing, term premium, foreign official sales, balance sheet policies

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1 Introduction

Understanding how changes in Treasury supply and demand affect Treasury yields is a question of fundamental importance for policymakers and market participants. Increases in Treasury yields lead to tighter financial conditions with real effects on economic activity through higher borrowing costs for the government, households, and firms. From a policy perspective, there is considerable interest in studying questions such as: "What would happen to yields if foreign official investors or the Federal Reserve reduce their Treasury holdings?"

A substantial literature has examined the impact of demand and supply shocks on Treasury yields using event studies, regressions, and affine term structure models (e.g., Gagnon et al., 2011; Krishnamurthy and Vissing-Jorgensen, 2012; Hamilton and Wu, 2012; Li and Wei, 2013) More recently, a growing literature builds on the demand-side asset pricing framework of Koijen and Yogo (2019), which provides an alternative approach to understanding Treasury securities pricing. This demand-side perspective gives us demand curves for each investor sector, allowing us to trace out how yields must adjust to equilibrate supply and demand.

Much of the existing empirical literature on Treasury demand system pricing has focused on estimating demand elasticities while either assuming constant holdings shares or using some historical average shares across investor groups (e.g., Eren et al., 2026; Chaudhary et al., 2026; Jansen et al., 2026). However, holdings shares change notably over time, particularly in response to major events such as quantitative easing programs, regulatory changes, and shifts in global savings. Understanding why this matters is crucial: changes in holdings shares affect counterfactuals about who will be the marginal buyers pricing additional supply. If highly price-sensitive investors increase their market share, the same supply shock will have a smaller yield impact than if price-insensitive investors dominate.

Capturing changes in holdings shares presents several empirical challenges. We need to construct smoothed holdings estimates from raw data that can be volatile and measured with error. Additionally, we need to address the important distinction between Treasury bills and bonds and treat them as different asset classes in the demand system framework, because the Treasury bills have no interest rate duration risks and serve primarily for cash management purposes while Treasury notes and bonds have duration risks. Moreover, some sectors such as money market funds hold predominantly bills and very little longer-duration securities.

This paper makes three main contributions. First, we develop a comprehensive demand system that estimates time-varying holdings shares for investor sectors using a Bayesian Dynamic Linear Model (DLM) with the constraint that shares sum to one. This approach allows holdings shares to evolve smoothly over time while ensuring internal consistency. Second, we estimate demand elasticities on Treasury bonds for these sectors using two-stage least squares (2SLS) with carefully selected instruments and controls to address both endogeneity and instrument strength. We find substantial heterogeneity in price sensitivity, with hedge funds and other private investors exhibiting elasticities an order of magnitude larger than pension funds and insurance companies. Third, we validate our model by decomposing historical yield changes into contributions from standard yield curve factors and changing investor base, showing that our estimated relationship between investor base and yields explain a significant portion of historical yield variation.

Our results show that the Treasury market has become more price-sensitive over time, primarily due to compositional shifts in the investor base. The declining participation of less price-sensitive foreign official investors, combined with the increasing role of more price-sensitive hedge funds and other private investors, has fundamentally altered market dynamics. In normal times, the elastic response of sensitive investors to yield changes dampens the effects of shocks. However, when these investors move to the sidelines during periods of stress, the market becomes suddenly much less elastic, amplifying the effects of shocks on yields.

We use our demand system to quantify yield effects from various hypothetical scenarios. Our estimates suggest that a $100 billion increase in Treasury supply raises yields by approximately 3 basis points under current market conditions, though this effect has varied considerably over time. We also examine the yield impact of large-scale sales by foreign official investors, and of Federal Reserve balance sheet policies, finding effects that are economically significant and roughly consistent with other models in the literature.

We caution however that our demand-system approach, like the broader literature, builds on Koijen and Yogo (2019) and estimates asset demand elasticities without a fully specified structural model of investor beliefs over the entire menu of asset payoffs. Fuchs et al. (2025) show that under such conditions, estimated demand elasticities are generally contaminated by an unobservable "latent mapping" linking preferences over risky payoffs to observed asset positions, and that supply-shock-based instrumental variable strategies—including ours—generically fail to isolate the ceteris paribus price variation needed for clean identification when asset payoffs overlap across the term structure, as Treasury securities of different maturities do. We thus view our estimated elasticities not as stable structural parameters but instead as reduced-form sample average parameters that are still useful for studying Treasury yield movements and policy implications.

The paper proceeds as follows. Section 2 presents the theoretical framework underlying our demand system approach. Section 3 describes our data and the empirical challenges we face. Section 4 details our estimation methodology, including the construction of time-varying holdings shares and the instrumental variables approach for the demand elasticity estimation. Section 5 discusses our estimated sectoral elasticities and their implications for market-level price sensitivity. Section 6 applies our framework to several policy-relevant scenarios. Section 7 validates the model by showing shifting investor base can meaningfully explain historical yield changes. Section 8 concludes and discusses directions for future research.

2 Theoretical Framework

2.1 Market Multiplier and Demand Elasticities

We begin by defining the yield elasticity of sector i as:[1]

$$\beta_i = \frac{d \ln H_i}{dy} \tag{1}$$

where H_i denotes the Treasury holdings of sector i and y is the representative Treasury yield. The holdings share of sector i is defined as $\omega_i = H_i/S$, where S represents total Treasury supply. The aggregate market demand elasticity is then:

$$\beta_M = \sum_{i=1}^{N} \omega_i \cdot \beta_i \tag{2}$$

The yield impact of a one percentage point exogenous change in Treasury supply is given by the market multiplier, the inverse of the market elasticity:[2]

$$\frac{dy}{dS/S} = \frac{1}{\beta_M} \tag{3}$$

This framework highlights that the aggregate yield response depends not only on individual sectoral elasticities but also on the composition of holdings. As holdings shares evolve over time, the market multiplier changes even if individual elasticities remain constant. This insight motivates our focus on time-varying holdings shares.

2.2 Microfoundations: Demand System Approach

Following Koijen and Yogo (2019), we assume that investors solve a portfolio choice problem with risk-return tradeoffs among available assets. Under their framework, returns have a

[1]We assume both the Treasury holdings and the Treasury supply are measured in face value terms, and for notational simplicity, we are ignoring the time subscript.

[2]This follows from the fact that market clearing requires: $dS = \sum_{i=1}^{N} dH_i = \sum_{i=1}^{N} H_i \beta_i dy$.

factor structure, and both expected returns and risks depend on asset characteristics.

A key result from Koijen and Yogo (2019) shows that the optimal portfolio simplifies significantly because information about other assets collapses to a scale variable that is constant across assets. This leads to a logit demand function where holdings depend on the asset's price and characteristics. Market clearing (total demand equals total supply) then determines equilibrium asset prices.

For sector i, the demand for Treasuries can be expressed in log portfolio share form:

$$\ln\left(\frac{H_i}{A_i}\right) - \ln\left(\frac{H_{i,0}}{A_i}\right) = \ln\left(\frac{H_i}{H_{i,0}}\right) = \alpha_i + \beta_i \cdot y + \phi_i \cdot X + \epsilon_i \tag{4}$$

where A_i represents total financial assets of sector i, $H_{i,0}$ is its holdings of the outside asset, y is the Treasury yield, X represents other asset characteristics and control variables, and β_i captures the sector's semi-elasticity of Treasury demand with respect to yields. Additionally, we assume that each sector's log portfolio share of the outside asset $\ln\left(\frac{H_{i,0}}{A_i}\right)$ is also a linear function of the control variables X (Koijen et al., 2021; Eren et al., 2026): $\ln\left(\frac{H_{i,0}}{A_i}\right) = c_i + b_i \cdot X$, which gives us the following equation for the empirical specification on the estimation of the yield elasticities:

$$\ln\left(\frac{H_i}{A_i}\right) = \alpha_i + \beta_i \cdot y + \delta_i \cdot X + \epsilon_i \tag{5}$$

3 Data and Empirical Challenges

Our analysis combines data from three primary sources. First, the Federal Reserve's Financial Accounts of the United States (Z.1 tables) provide quarterly holdings data for domestic sectors, including households, financial institutions, pension funds, insurance companies, and government entities. Second, the Treasury International Capital (TIC) system provides monthly data on foreign official institutions and foreign private investors, including detailed geographic breakdowns. We supplement these holdings data with Treasury yield data and macroeconomic controls, including the five-year Treasury yield, CPI inflation, U.S. corporate profit rate, S&P 500 index, Brent crude oil price, the dollar index, VIX, Treasuries bonds and bills outstanding held by the public, and short-term interest rates.[3]

3.1 Sector Definitions

In the Flow of Funds Z.1 data, Treasury holdings (measured at market value) are grouped into 25 investor sectors: household, nonfinancial corporate business, nonfinancial noncorporate business, state and local governments, central bank, U.S.-chartered depository institutions, foreign banking offices in U.S., banks in U.S.-affiliated areas, credit unions, property-casualty insurance companies, life insurance companies, private pension funds, federal government pension funds, state and local government, pension funds, money market funds, mutual funds, closed-end funds, exchange-traded funds, government-sponsored enterprises, ABS issuers, brokers and dealers, holding companies, other financial business, rest of the world. There is also a discrepancy sector in the Z.1 data, which at times has been large (over $2 trillion), that captures any missing holdings and the cumulated valuation difference between issuance and holdings.

We make several adjustments to the Z.1 data. First, for ease of interpretation, we collapse some of these categories into larger groups. We combine private and public pensions funds into a single category, and we also combine U.S.-chartered depository institutions, foreign banking offices in the U.S., banks in U.S.-affiliated areas, bank holdings companies, and credit unions into a single category called "banks." Finally, we use the TIC data to separate the Rest of World sector in the Flow of Funds data into foreign official investors and foreign private investors, which have been shown to respond differently to changes in yields (Tabova and Warnock, 2026). We are particularly interested in the most price sensitive investors

[3]These data are sourced from the Federal Reserve Economic Data (FRED), produced by Research Department at the Federal Reserve Bank of St. Louis. To derive the corporate profit rate, we use corporate profits with inventory valuation and capital consumption adjustments of domestic industries, from the Bureau of Economic Analysis, scaled by U.S. nominal GDP. The mnemonic for corporate profit series in FRED is A445RC1Q027SBEA.

that drive the overall market elasticity. To that end, we create a new "Household and Hedge Funds" (HHF) category comprising households, domestic hedge funds, and foreign-domiciled investment funds (including foreign hedge funds). In the Z.1 tables, holdings of the household sector are estimated residually and already include holdings of domestic hedge funds by design. But the household sector holdings also inadvertently include Treasury holdings of Cayman domiciled hedge funds involved in the Treasury cash-futures basis trade that are mistakenly not captured in the TIC data (Barth et al., 2025). Instead of trying to separate out the hedge funds from the household sector, we group them together and add additional holdings of selected investment funds from the TIC data. Specifically, we add TIC Treasury holdings from countries that are known to be popular domiciles for hedge funds and other investment fund vehicles, namely the Caribbean tax havens (Bahamas, Bermuda, Cayman Islands, Netherlands Antilles), Ireland, and Luxembourg.[4] Finally, we recompute the statistical discrepancy using total Treasuries outstanding and our redefined sector holdings, and allocate it to the Household and hedge fund sector.[5].

Table 1 shows the holdings of total Treasury securities (bills, notes, and bonds) for the newly derived groups. Bills holdings are broken out for 6 of the 18 sectors that report them. With holdings of over $6 trillion, the Household and Hedge Funds group holds a fifth of Treasuries outstanding.

3.2 Empirical Challenges

Several challenges complicate our estimation. First, both prices and holdings are endogenous. Portfolio decisions affect yields through market clearing, and yields simultaneously affect portfolio allocations. Ordinary least squares estimation produces elasticities that are

[4]The TIC data capture only a small fraction of Treasuries held by Cayman Island investors, which we allocate to the HHF group. The holdings we added from these countries are excluded from the foreign private investors group to avoid double counting.

[5]We allocate the discrepancy to the Household and Hedge Funds (HHF) sector for two reasons: (1) HHF includes the household sector that is already estimated residually in the Z.1 data, and (2) the discrepancy could reflect missing hedge fund holdings, as there is some evidence suggesting that holdings of hedge funds and other leveraged investors may be under-reported in the TIC and Z.1 data (Barth et al., 2025)

Table 1: Holdings of Treasury Securities by Investor Sector (billions of dollars), as of 2026:Q1

Sector	**Total ($bn)**	**Share (%)**	**T-Bills ($bn)**
Sectors for which we estimate elasticities:			
1. Households and hedge funds	6136	16.7	–
Of which: Households (incl. dom. hedge funds)	3039	8.3	–
Of which: Selected Foreign Inv. funds (TIC)	1492	4.1	455
Of which: Discrepancy	1606	4.4	–
2. Asset-Backed Securities Issuers	19	0.1	–
3. Exchange-Traded Funds	779	2.1	–
4. Mutual Funds	1694	4.6	–
5. Foreign Private Investors	3959	10.8	1075
6. Property-Casualty Insurance	391	1.1	206
7. Nonfinancial Business	225	0.6	–
8. Closed-End Funds	2	0.0	–
9. Foreign Official Investors	3905	10.6	444
10. Life Insurance Companies	207	0.6	24
11. Pension Funds	1203	3.3	–
12. Banks and Bank HCs	2170	5.9	–
13. Broker-Dealers	620	1.7	–
Sectors used to define instrument in IVREGs:			
14. State and Local Governments	1560	4.2	–
15. Government-Sponsored Enterprises	243	0.7	–
16. Other Investors	102	0.3	–
17. Federal Reserve	4000	10.9	393
Sectors used only in derivation of holding shares:			
18. Money Market Funds	3426	9.3	2468
Sector unknown	–	–	1756
Total Holdings	**30642**	**100.0**	**6819**
Total Outstanding	**30642**	**100.0**	**6819**

Note: Household and Hedge Funds (HHF) also includes the statistical discrepancy in bond holdings. Foreign Private Investors excludes Treasury holdings by investors in tax havens (Bahamas, Bermuda, Cayman Islands, Dutch Caribbean, Luxembourg, Ireland), which are in HHF to avoid double-counting. “Sector unknown” represents T-Bills held by sectors that do not report T-Bill breakdowns separately (computed by residual); these are included in those sectors’ total holdings. ‘–’ indicates no reported T-Bill holdings. Source: Financial Accounts of the U.S. (Z.1) and Treasury International Capital (TIC) data.

implausibly low due to this simultaneous causation. Second, log holdings shares exhibit strong persistence. A sector's portfolio weight today depends heavily on its weight yesterday, both due to slow adjustment and to the fact that portfolio rebalancing responds to returns as well as expected returns. This persistence must be carefully controlled for in the regressions.

Third, different investors are affected by different demand shocks. We estimate yield elasticities using investor-type-specific 2SLS specifications because different investor classes (banks, insurance companies, pension funds, foreign investors) face fundamentally distinct regulatory constraints, liability structures, tax treatments, and risk mandates—that shift their demand curves through different channels. A pooled specification with uniform controls imposes the counterfactual restriction that all investors share identical demand functions, producing omitted variable bias when investor-specific confounders (e.g., capital ratios for banks, liability duration for pensions) are correlated with both yields and quantities demanded. Critically, we find that instrument strength depends on the conditioning set: the same demand shifter may generate strong first stage test statistics for one investor type after controlling for investor-specific factors but produce weak instruments under pooled controls that average across heterogeneous responses. Moreover, conditional exogeneity requires that the explanatory variables include all variables affecting investor i's demand that correlate with instruments; since these confounders differ across investor types, a common control set necessarily violates the exclusion restriction for some investors. The pooled estimator therefore recovers a variance-weighted average of heterogeneous elasticities contaminated by bias from excluded investor-specific demand shifters, precluding valid inference about any actual investor type's price responsiveness and misidentifying the cross-sectional distribution of elasticities necessary for policy counterfactuals involving portfolio rebalancing across heterogeneous investors.

Finally, we do not observe separate holdings of bonds versus bills for 12 out of the 18 sectors in our demand system. This matters because in order to estimate the market multiplier of bond holding changes' effects on bond yields, we need to know the shares of bonds outstanding held by each investor type. Furthermore, bills are closer substitutes for other money market instruments than for longer-duration bonds. Money market funds, for example, hold predominantly bills, and their demand for bills may have different characteristics than other sectors' demand for bonds (Jansen et al., 2026).

3.3 Instrumental Variable Strategy

To address endogeneity, we employ an instrumental variables approach using exogenous net supply shocks. Our primary instrument is the share of Treasury bonds held by the Federal Reserve and other price-insensitive sectors (GSEs, state and local governments, and other). Its identifying logic is that these holders' Treasury demand is driven by policy, regulatory, and liquidity motives that shift the residual supply facing private, price-sensitive investors, while being plausibly orthogonal to any single private sector's idiosyncratic demand shock.[6]:

$$\text{Instrument}_t = \frac{\text{Fed Holdings}_t + \text{GSEs}_t + \text{State and Local Governments}_t + \text{Other Holdings}_t}{\text{Market value of Treasury Bonds Outstanding}_t} \tag{6}$$

This instrument satisfies the relevance condition because Federal Reserve holdings, particularly during quantitative easing periods, directly affect Treasury yields through supply and demand effects. The instrument satisfies the exclusion restriction because Fed policy decisions are based on macroeconomic conditions and policy mandates, not on any particular sector's portfolio optimization decisions.[7] We control for macroeconomic conditions in both stages of the 2SLS procedure, ensuring that the instrument captures supply effects rather than demand shifts correlated with the business cycle.

[6] We get broadly similar results if we use only the Federal Reserve's Treasury bond holdings as the instrument.

[7] The validity of the instrument rests on the assumption that Federal Reserve asset purchases are determined by monetary policy objectives related to aggregate economic conditions, rather than by microeconomic portfolio considerations of typical individual sectors that optimize the return-risk tradeoff. During the quantitative easing periods, the Fed announced and implemented purchases according to pre-specified schedules, reducing the scope for endogenous responses to sector-specific shocks.

4 Estimation Methodology

4.1 Time-Varying Holdings Shares

We estimate time-varying holdings shares using a Bayesian Dynamic Linear Model (DLM), as described in (West and Harrison, 1997). The Bayesian DLM offers several advantages. First, the adding-up constraints are enforced through the constraint equations, ensuring that estimated shares sum to one at each point in time. Second, the state-space framework naturally handles sectors that do not report T-bond vs T-bill breakdowns. For these sectors, we observe only total holdings, and the model uses the constraint equations and information from other sectors to infer the bond-bill split. Third, the random walk state evolution with small innovation variances produces smooth holdings share trajectories that reflect gradual portfolio rebalancing in response to secular trends (e.g., slower growth of foreign exchange reserves, growth of hedge funds) rather than erratic quarter-to-quarter fluctuations.

For each of the 18 sectors (covering both bonds and bills where data permit), we specify:

$$H_{i,t}^{Bonds} = \gamma_{i,t}^{Bonds} \cdot S_t^{Bonds} + \epsilon_{i,t}, \qquad H_{i,t}^{Bills} = \gamma_{i,t}^{Bills} \cdot S_t^{Bills} + \epsilon_{i,t} \tag{7}$$

or

$$H_{i,t} = \gamma_{i,t}^{Bonds} \cdot S_t^{Bonds} + \gamma_{i,t}^{Bills} \cdot S_t^{Bills} + \epsilon_{i,t}, \tag{8}$$

linking holdings of bonds or bills (H) to their amounts outstanding (S) via the holdings shares (γ). In other words, for each sector, the observation equations are either the holdings of Treasury bills versus bonds if the bills-bonds split is available, or the total holdings of both bills and bonds if such split is not available.

The holding shares evolve as random walks:

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t} \tag{9}$$

where $\eta_{i,t} \sim N(0, \sigma_\gamma^2)$.

To ensure smoothness, we set the state innovation variance to a very small value, allowing gradual evolution. We impose the adding-up constraints:

$$\sum_{i=1}^{N} \gamma_{i,t}^{Bonds} = 1, \quad \sum_{i=1}^{N} \gamma_{i,t}^{Bills} = 1 \tag{10}$$

as explicit observation equations in the state-space system. We assume that money market funds only hold Treasury bills. We also assume that the household and hedge funds only hold bonds to reduce the number of state variables. This assumption is supported by findings of Tabova and Warnock (2026) that shows that private investors prefer longer duration securities, and by the fact that the substantial holdings of Treasuries by hedge funds involved in the Treasury cash-futures basis trade are Treasury notes and bonds, not bills (Barth and Kahn, 2025). Appendix A provides additional details of the estimation.

The Kalman filter and smoother produce optimal estimates of the time-varying shares $\{\gamma_{i,t}\}_{t=1}^{T}$ given the full sample of data.[8] As a validation test of our approach in estimating holding shares for bills and bonds separately, Figure 1 shows how the estimated shares of bonds compare with the actual reported holding shares for the Federal Reserve and the Life insurers, using only their combined holdings of bills and bonds in the estimation. The estimated bond holdings shares seem to capture the overall level and variation in the reported data relatively well.

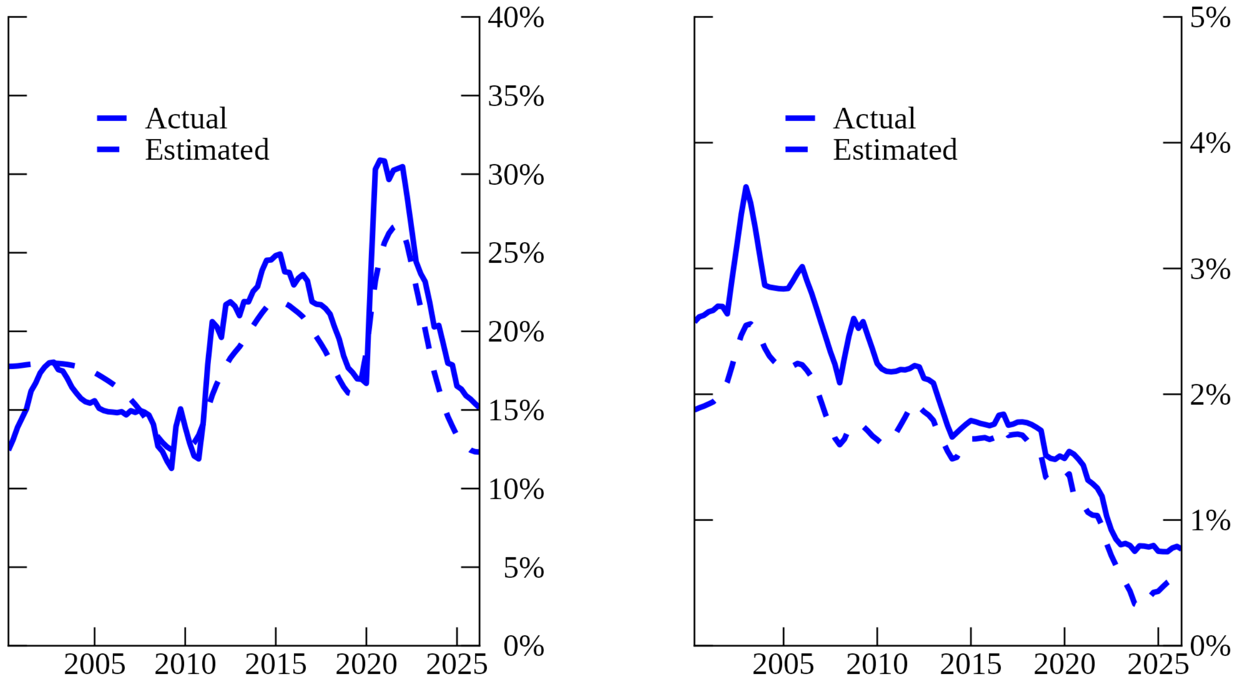
Having validated our approach, we now proceed to use each sector's reported total holdings, or bills versus bonds holdings when available, to estimate its bond holding shares. Figure 2 shows the estimated smoothed bond holdings shares for individual sectors, while Figure 3 aggregates these sectors by price sensitivity that we will estimate and discuss later, where we have colored the sectors in orders of the magnitudes of their estimated yield elasticities. Note that some individual sectors could have negative bond holdings because it is a residual sector (e.g. the household sector in the HHF group) or a financial intermediary sec-

[8] Estimation is done using the 'dlm' package in R contributed by Petris (2010).

tor (i.e. broker-dealer sector, or BDS). The two figures show that there are notable variations in the investor compositions of the Treasury bond market after the 2008-2009 Global Financial Crisis (GFC), with Foreign Official Investors (FOI) becoming a smaller player while the Household and Hedge Funds (HHF) becoming a larger player, especially after 2022.

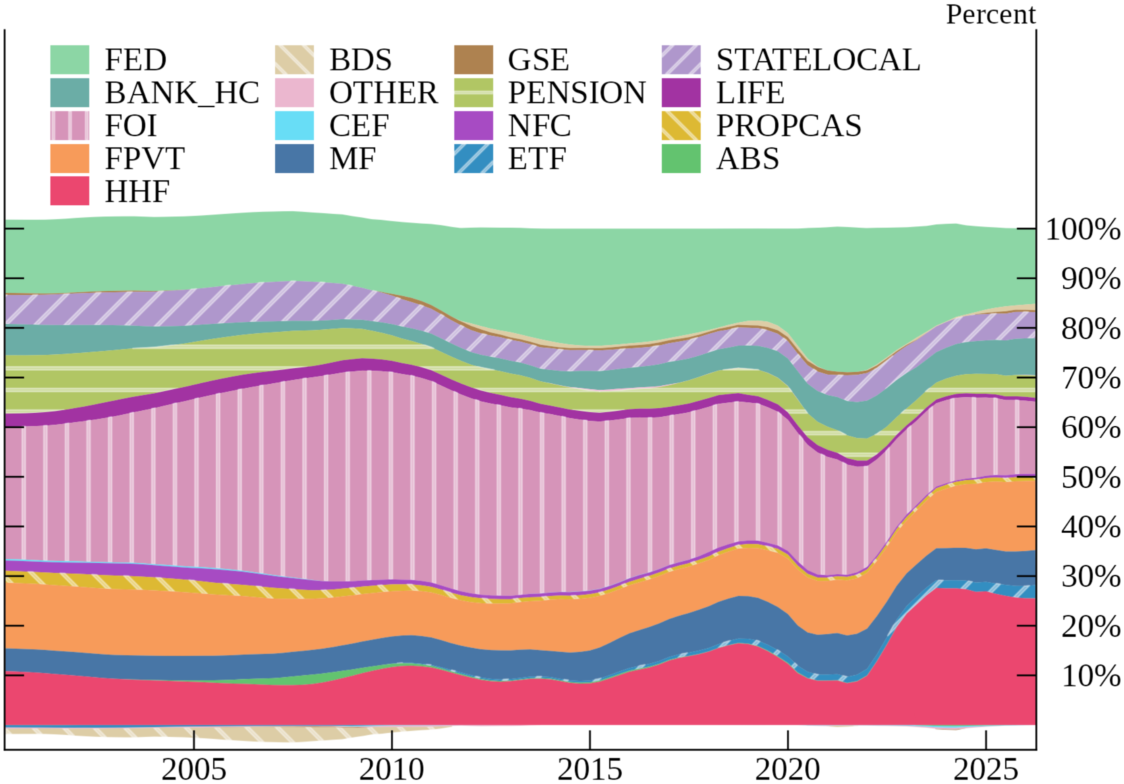
Figure 1. Estimated Versus Actual Bond Holdings Shares.

(a) Federal Reserve **(b)** Life Insurers



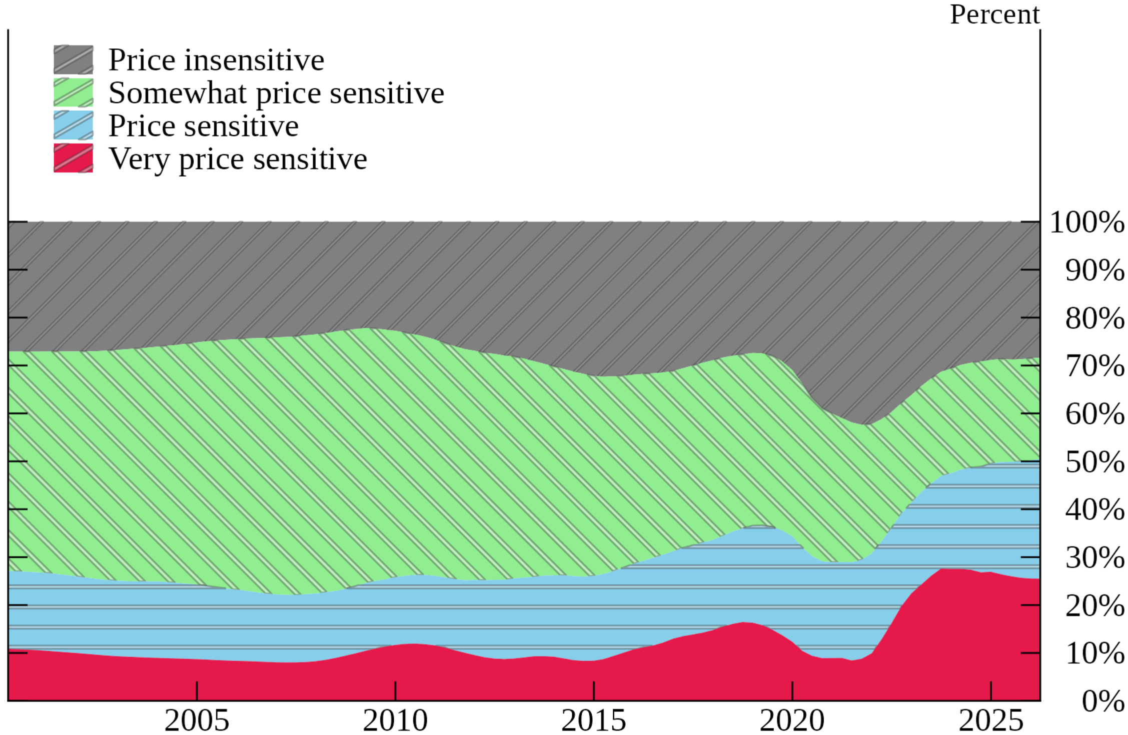
Note: Bond holdings shares for the Federal Reserve and life insurance sectors are estimated in separate models that use their combined holdings of short-term and long-term Treasuries, respectively, alongside the holdings of the other sectors.

Figure 2. Smoothed Treasury Bond Holdings Shares by Individual Sector



Note: Smoothed bond holdings shares are constructed using the Dynamic Linear Model (DLM) estimates on the raw holdings shares from the Z1 and TIC Treasury holdings data. The Household and Hedge Funds (HHF) group includes the Household sector (including domestic and Cayman domiciled hedge funds), Foreign private holdings in Caribbean, Luxembourg, Ireland from the TIC, and the discrepancy in bond holdings. We use the TIC data to split the ROW sector in the Z1 data into Foreign Official Institutions (FOI) and Foreign Private Investors (FPVT), and for FPVT, we subtract these holdings included in the HHF group.

Figure 3. Smoothed Holdings Shares Grouped by Price Sensitivity



Note: Smoothed bond holdings shares are constructed using the Dynamic Linear Model (DLM) estimates on the raw holdings shares from the Z1 and TIC Treasury holdings data. The very price sensitive group includes the Household sector (including domestic and Cayman domiciled hedge funds), foreign private holdings in Caribbean, Luxembourg, Ireland from the TIC, and the discrepancy in bond holdings. The price sensitive group includes security brokers and dealers, foreign private investors, ETF, and ABS issuers. The somewhat price sensitive group includes foreign official institutions, mutual funds, pension funds, life insurance companies, property-casualty insurance, non-financial business. The price insensitive group includes banks and bank holding companies, state and local governments, government sponsored enterprises, Federal Reserve, and other sector.

4.2 Elasticity Estimation via Two-Stage Least Squares

Since we assume the MMF sector only holds bills and we use the bond holdings of Federal Reserve, GSEs, State and Local Government, and the Other sector as the instrument, we only need to estimate the elasticity for the remaining 13 sectors. For each of these 13 sectors, we estimate the semi-elasticity of Treasury bond demand with respect to yields using 2SLS over the sample 2009Q1 to 2022Q1 (excluding 2020Q1 due to COVID-19 volatility). The estimating equation is:

$$s_{i,t} = \alpha_i + \beta_i \cdot y_t + \lambda_i \cdot s_{i,t-1} + \mathbf{X}_t' \boldsymbol{\delta}_i + \epsilon_{i,t} \tag{11}$$

where $s_{i,t} = \ln(H_{i,t}/A_{i,t})$ is the log *bond* holdings share (i.e. no bills), y_t is the five-year Treasury yield, $s_{i,t-1}$ captures persistence in holdings as investors only adjust their portfolio weights slowly in practice, and $\mathbf{X}_t$ contains control variables.

The first stage regresses the yield on the instrument and controls:

$$y_t = \pi_0 + \pi_1 \cdot \text{Instrument}_t + \mathbf{X}_t' \boldsymbol{\pi}_2 + \nu_t \tag{12}$$

The second stage uses the predicted yield $\hat{y}_t$ from the first stage:

$$s_{i,t} = \alpha_i + \beta_i \cdot \hat{y}_t + \lambda_i \cdot s_{i,t-1} + \mathbf{X}_t' \boldsymbol{\delta}_i + \epsilon_{i,t} \tag{13}$$

For each sector, we initially tried including all of the following control variables: log dollar, log VIX, corporate profit rate, TED spread, oil prices, log S&P500 index, and CPI inflation. We find that many sectors suffer from a weak instrument problem with this approach as many of these control variables are also strongly correlated with Treasury yields (see appendix B for the estimation results using the full set of controls for each sector). As a result, we use an alternative approach that selects the optimal combination of controls that maximizes the absolute t-statistic on the elasticity estimate. This sector-specific control selection allows for heterogeneity in the relevant demand shifters across investor types.

Table 2 presents results about the two-stage least squares specifications and the diagnostic tests for weak instruments and endogeneity. The t-statistics reveal that most of the 13 main sectors have significantly positive elasticities at the 5% level, with several sectors showing particularly strong statistical significance ($|t| > 3.0$): HHs and hedge funds (aggregate), ABS issuers, ETFs, Mutual funds, Foreign private, Property & casualty, and Foreign official. The diagnostic tests confirm the strength of the instrumental variable across all 13 sectors. F-statistics range from 15.69 to 58.67, all well above the conventional threshold of 10, indicating strong first-stage instruments throughout. The Wu-Hausman test results show significant endogeneity ($p < 0.05$) for most of the sectors, justifying the use of IV estimation rather than OLS. As a robustness check, Appendix B describes an alternative approach to select the controls for each sector using cross-validated LASSO (Belloni et al., 2012). The elasticity estimates from this alternative approach are broadly similar to those in table 2.

Table 2: Treasury Demand Elasticities: IV Regression Diagnostics

Sector	Controls	Elasticity	HAC t	1st st. F-stat	WH	WH p-value
1. HHs & Hedge funds	X2+X6	40.53***	4.46	15.69	18.82	0.000
HHs (incl. domestic HFs)	X2+X4+X5	26.74***	4.86	53.87	17.66	0.000
Selected Foreign inv. funds	X1+X5+X7	3.41***	2.95	75.00	13.70	0.001
2. ABS issuers	X2+X4+X5+X6	10.16***	4.35	39.31	2.47	0.123
3. ETFs	X2+X7	10.37***	6.20	49.74	9.28	0.004
4. Mutual funds	X1+X3+X5	7.29***	3.21	28.92	7.18	0.010
5. Foreign private	X3+X7	9.60***	3.45	19.55	15.54	0.000
6. Prop. & casualty	X2+X3+X4+X7	8.27***	4.04	37.52	13.92	0.001
7. Nonfinancial bus.	X2	5.50**	2.07	44.91	6.49	0.014
8. Closed-end funds	X1+X2+X4+X5+X7	2.05*	1.87	43.20	0.07	0.799
9. Foreign official	X1+X3+X5+X7	2.11***	5.76	24.76	5.16	0.028
10. Life insurance	X2	2.45**	2.02	55.99	6.93	0.011
11. Pension funds	X3+X6	2.69**	2.67	45.22	0.42	0.518
12. Banks & bank HCs	X1+X5+X7	-6.36**	-2.38	31.45	6.06	0.018
13. Broker dealers	X2+X6+X7	12.14**	2.35	58.67	5.64	0.022

This table presents Treasury demand elasticities estimated using two-stage least squares regressions with instrumental variables. The estimation sample covers 2009:Q1 to 2022:Q1, excluding 2020:Q1. The elasticity measures the percentage change in Treasury holdings in response to a one percentage point change in the 5-year Treasury yield. The t-statistic is based on HAC (Newey-West, lag 3) standard errors and tests the null hypothesis that the elasticity equals zero. The F-statistic tests for weak instruments in the first stage regression. The Wu-Hausman (WH) test assesses endogeneity of the Treasury yield variable.
Control variables: All regressions include lagged holdings and the Treasury instrument. Additional controls vary by sector: X1 = log broad nominal US dollar index; X2 = log VIX index; X3 = US corporate profit rate; X4 = TED spread; X5 = Brent crude oil futures price; X6 = log S&P 500 index; X7 = CPI inflation. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5 Results

5.1 Sectoral Demand Elasticities

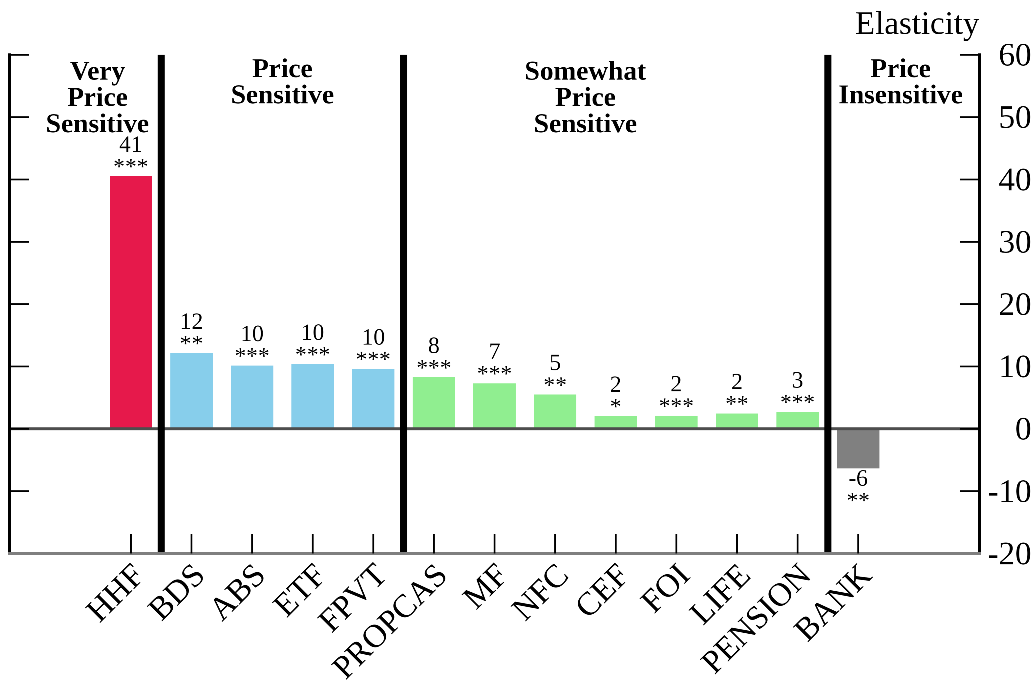
Figure 4 presents our elasticity estimates grouped into four main groups by the magnitudes. As in Chaudhary et al. (2026), we find substantial heterogeneity in yield sensitivity across sectors. In the very price sensitive group, the HHF sector (hedge funds and households) exhibits a very large elasticity of around 41, meaning that a one percentage point increase in yields, which corresponds to about a 5 percentage point price drop on the representative 5-year Treasury bond, raises their Treasury holdings by 41 percentage points. At the other extreme in the price insensitive group, banks have a significantly negative elasticity of about -6, possibly because they hold bonds primarily for regulatory purposes and kept increasing their Treasury holdings in the period after the GFC even as Treasury yields were declining (i.e. Treasury bond prices were increasing).

Broker-dealers, surprisingly, show a medium-high elasticity of about 12. ABS issuers, ETFs, and foreign private investors also show medium-high elasticities at about 10, reflecting their role as price-sensitive investors.

Property-casualty insurers, mutual funds, and nonfinancial corporations have moderate elasticities of 5 to 8, as they hold Treasuries also for liquidity and regulatory purposes rather than just for total return.

In contrast, foreign official institutions, pension funds, and life insurance companies show low elasticities. The low elasticity of foreign official institutions likely reflects their role as reserve managers who hold Treasuries primarily for safety and liquidity rather than yield. This finding is consistent with the "exorbitant privilege" literature, which emphasizes that demand for safe dollar-denominated assets is relatively insensitive to yields (Tabova and Warnock, 2026). Similarly, pension funds and life insurance companies exhibit low elasticities, consistent with their role as buy-and-hold investors with long-duration liabilities.

Figure 4. Estimated Demand Yield Elasticities by Sector (2SLS)



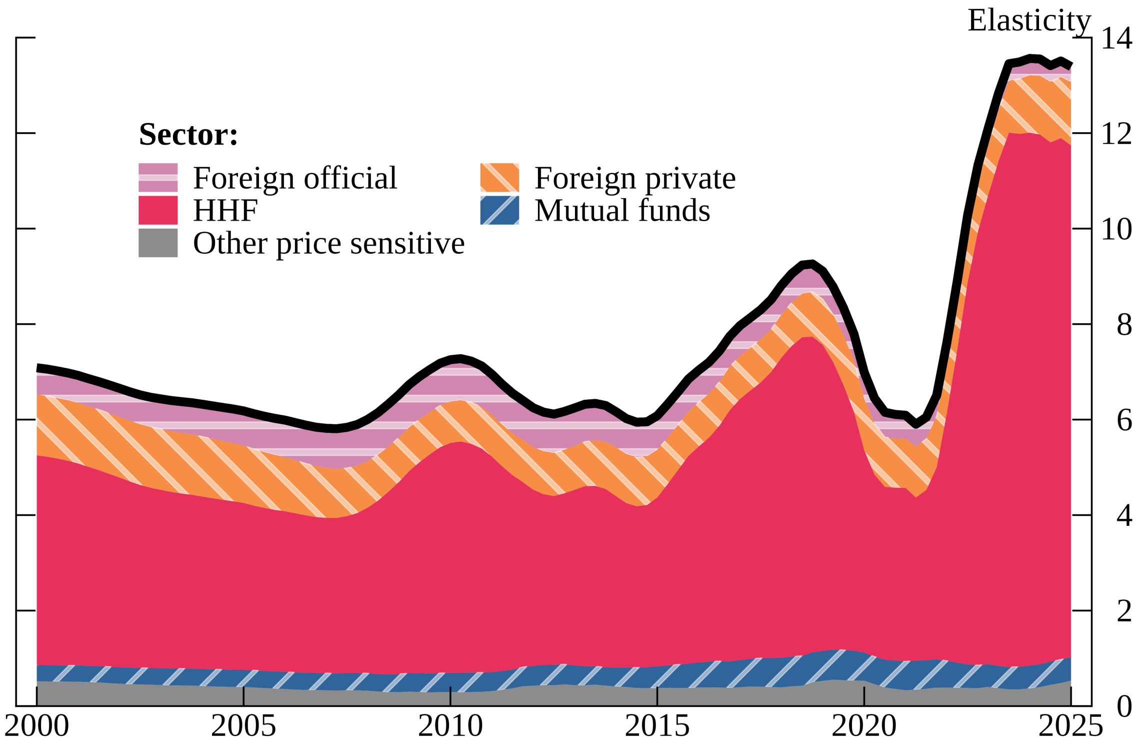
Note: Sector Definitions are as follows: HHF: Households, hedge funds, and discrepancy in holdings data. BDS: Broker dealers, ABS: ABS issuers, ETF: Exchange traded funds, FPVT: Foreign private investors (excluding selected foreign investment funds from TIC data), PROPCAS: Property and casualty ins., MF: Mutual funds, NFC: Nonfinancial business, CEF: Closed-end funds, FOI: Foreign official investors, LIFE: Life insurance companies, PENSION: Pension funds, BANK: Banks and bank holding companies. The estimation sample is 2009:Q1 to 2022:Q1, excluding 2020:Q1. Elasticities are estimated using two-stage least squares, as described in notes to Table 2. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5.2 Growing Importance of Price-Sensitive Investors

A key finding emerges when we combine the elasticity estimates with time-varying holdings shares. Figure 5 decomposes the aggregate market elasticity into contributions from each sector, using both the sectoral elasticity and the sector's share of the market over time.[9]

[9] We assume banks, MMF, state and local governments, government sponsored enterprises, and the other sector have zero elasticity in computing the market elasticity.

Figure 5. Sectoral Contributions to Market Elasticity Over Time



Note: This figure decomposes the aggregate market elasticity (the black line) into contributions from each sector, showing both the estimated sectoral elasticity and the sector's estimated share of the market over time. The estimated market elasticity represents the percentage points change in total Treasury market holdings for one percentage point increase in Treasury yields.

The figure reveals a striking evolution in market structure. In the early 2000s, foreign official investors held a large share of the market, but their low elasticity meant they contributed only modestly to aggregate price sensitivity. Over time, as shown previously in figure 2, foreign official holdings declined as a share of the total, while holdings of HHF investors (hedge funds and households) increased. Because HHF investors have very high elasticities, their rising market share substantially increased aggregate market elasticity.

This compositional shift has important implications for yield dynamics. In normal times, the presence of highly elastic investors such as hedge funds dampens yield responses to supply or demand shocks—small yield changes are sufficient to induce these investors to adjust their portfolios. However, this also creates fragility risk: if these elastic investors become impaired or step back from the market during stress periods, the market becomes suddenly much less elastic, and shocks can generate large yield movements.

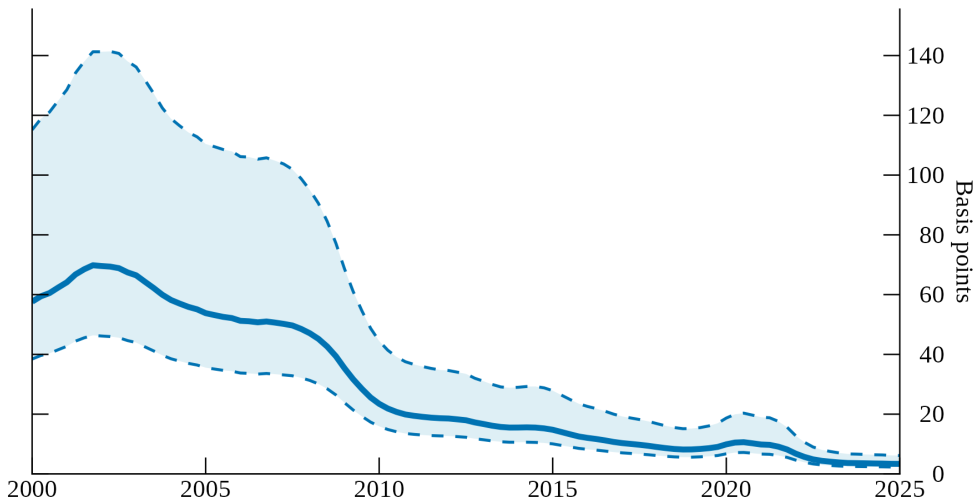
5.3 Yield Effects of Treasury Supply Changes

Combining our elasticity estimates with time-varying holding shares, we can now compute the path of market multiplier over the last quarter century, and the implied yield effects from increases in the supply of Treasury bonds.[10] The solid blue line in the top panel of Figure 6 shows the estimated yield impact that a $100 billion increase in Treasury bond supply would have had at each point in time since 2000 along with the 95% confidence intervals constructed using the elasticity point estimates and t- statistics reported in Table 2. The estimated effect has declined over time, from around 65 basis points in the early 2000s to approximately 3 basis points currently. Most of this decline reflects the fact that $100 billion today is a much smaller share of the market than it was a quarter century ago: the stock of Treasury bonds held by the public has grown from $2.5 trillion in 2000 to $23.8 trillion as of 2026:Q1. Some of the decline in the estimated yield effect also reflects the rising market share of more elastic investors who can absorb supply increases with smaller yield changes. For comparison, the solid blue line in the bottom panel shows the implied yield effects and the associated 95% confidence interval from an increase in Treasury bond supply equivalent to 1% of Treasury bonds outstanding. With this normalization of the supply shock, an increase in Treasury bond supply of 1% has a relatively stable estimated yield effect at around 15 basis points from 2000 to 2015. The estimated effect then declined until about 2019, and increased back to its earlier level in 2021-2022 before declining again, and is currently at about by 8 basis points as of 2026:Q1.

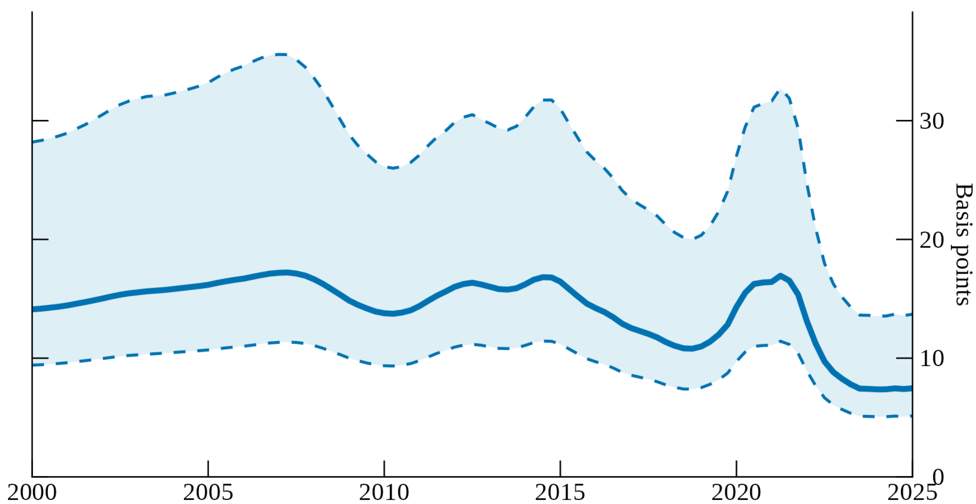
[10]With the lagged holdings included in the elasticity estimation equation, the estimated elasticity β_i is the short-run one-quarter yield elasticity while the long-run response is $\frac{\beta_i}{(1-\lambda_i)}$. All the results reported subsequently in the paper are based on the short-run elasticity for simplicity. Since the long-run elasticity is typically larger than the short-run elasticity, the implied yield effects in the long-run are typically smaller than these reported.

Figure 6. Yield Impact of Increase in Treasury Bond Supply

(a) Increase of $100 billion



(b) Increase of 1% of outstanding



Note: Yield impact is derived using Equation 3 and our estimated (fixed) elasticities and (time-varying) holding shares. The 95% confidence intervals shown by the dashed lines are constructed using the elasticity point estimates and t-statistics reported in Table 2. At end-2026.Q1, yield effects are 3.2 and 7.6 basis points for $100 billion and 1% supply increases, respectively.

These magnitudes are economically plausible and roughly consistent with other approaches in the literature using event studies or term structure models to estimate the yield effects of QE programs.

6 Policy Applications

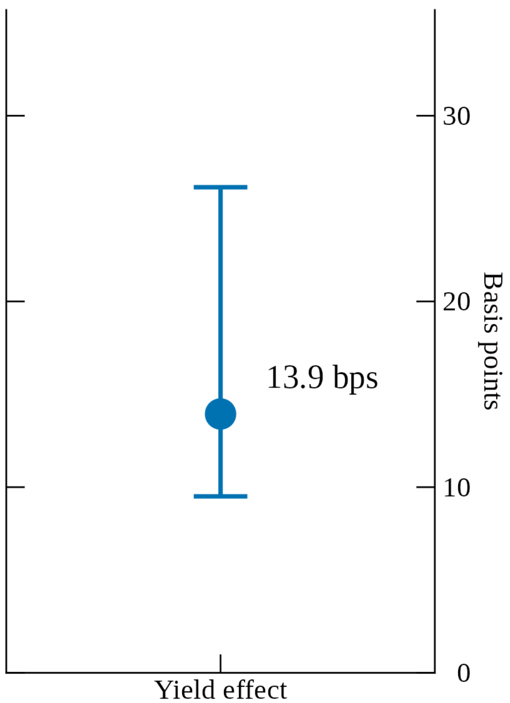
In this section, we apply our model estimates to a few scenarios to quantify the potential effects on Treasury yields from changes to Treasury demand.[11] The yield impact depends on two key factors: (1) the amount of Treasuries that must be absorbed from net sales, and (2) which investors are buying versus sitting out. Crucially, yields are determined by the composition of active investors remaining in the market as their demand elasticities collectively determine the new market multiplier following the shock.

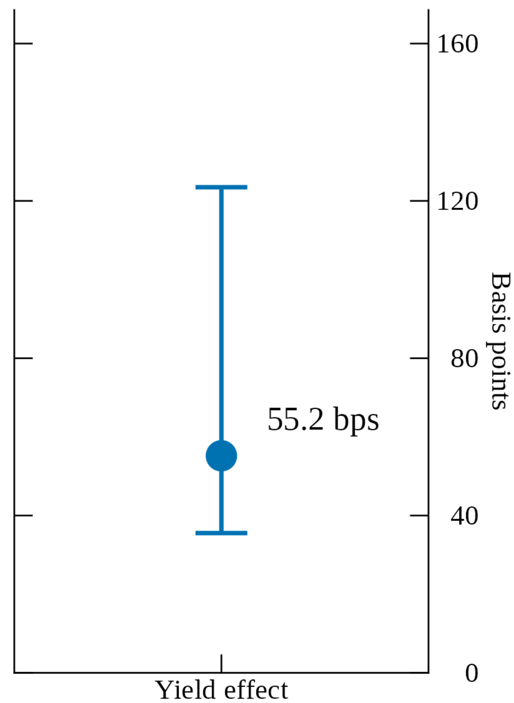
6.1 Sales by Foreign Official Investors

A potential concern for policymakers is upward pressure on Treasury yields stemming from large sales of Treasury bonds by foreign official investors (FOIs). Figure 7a shows the estimated yield effect and its 95% confidence interval of a hypothetical $500 billion sale by FOIs.

[11] A caveat applies to these simulations. Fuchs et al. (2025) show that asset demand elasticities estimated without a fully specified model of investor beliefs over future payoffs may not be invariant to these types of shocks. For example, sustained large sales of Treasuries by FOIs or the Fed could alter market expectations about future Treasury supply or monetary policy, which in turn could shift the (unobserved) mapping from investor preferences to portfolio holdings, and hence the sectoral elasticities that we currently assume to be fixed. Our estimates should therefore be interpreted as a first-order, partial-equilibrium approximation rather than a fully structural counterfactual.

Figure 7. Yield Effect of Sectoral Sales of $500 Billion





Note: The bars around the dot show the 95% confidence interval. In the left panel, foreign official investors are assumed to be on the sidelines and thus unable to absorb any sales. In the right panel, the HHF sector is assumed to be on the sidelines and thus unable to absorb any sales, which increases the market multiplier because their exit makes the overall market less elastic.

Under current market conditions, a $500 billion sale by the FOIs would raise yields by about 14 basis points. This is economically significant but manageable, reflecting the fact that the remaining investor base has sufficient yield sensitivity to absorb the sales without extreme yield movements.

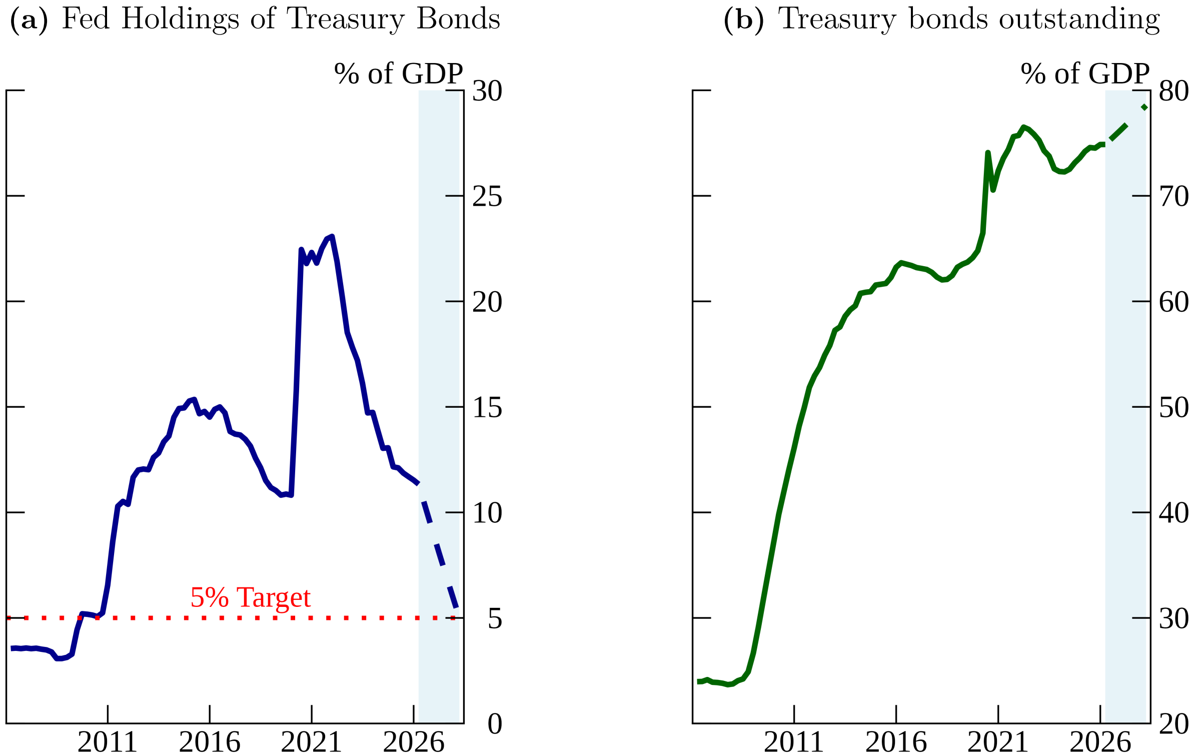
For comparison, Figure 7b shows the implied yield effect and its 95% confidence interval of a hypothetical $500 billion sale by households and hedge funds (HHF). Because these investors have a much higher elasticity, their absence from the market means that the market elasticity from the remaining less yield-sensitive investors becomes smaller. As a result, absorbing the same amount of sales by HHF investors by the remaining investors requires a much larger yield increase of about 55 basis points in order to clear the market.

6.2 Federal Reserve Balance Sheet Policy

Another application of our framework is assessing the yield impact of the Federal Reserve balance sheet policy. For example, should the Fed decide to substantially reduce its \$4+ trillion Treasury portfolio while net Treasury issuance continues to grow, private markets would face a historic supply shock. The yield impact would depend crucially on which investors step in—yet existing models often treat all buyers as homogeneous. To quantify these potential effects, we simulate a hypothetical scenario in which the Fed reduces its Treasury holdings to 5% of GDP over eight quarters, while Treasury issuance continues at 5% annual growth and GDP grows at 2.5% annually.

Figure 8a shows the assumed path of Fed holdings as a percentage of GDP, declining from current levels to the 5% target, while Figure 8b shows the corresponding evolution of Treasury bonds outstanding as a percentage of GDP.

Figure 8. Assumptions for Hypothetical Fed Balance Sheet Shrinkage Scenario

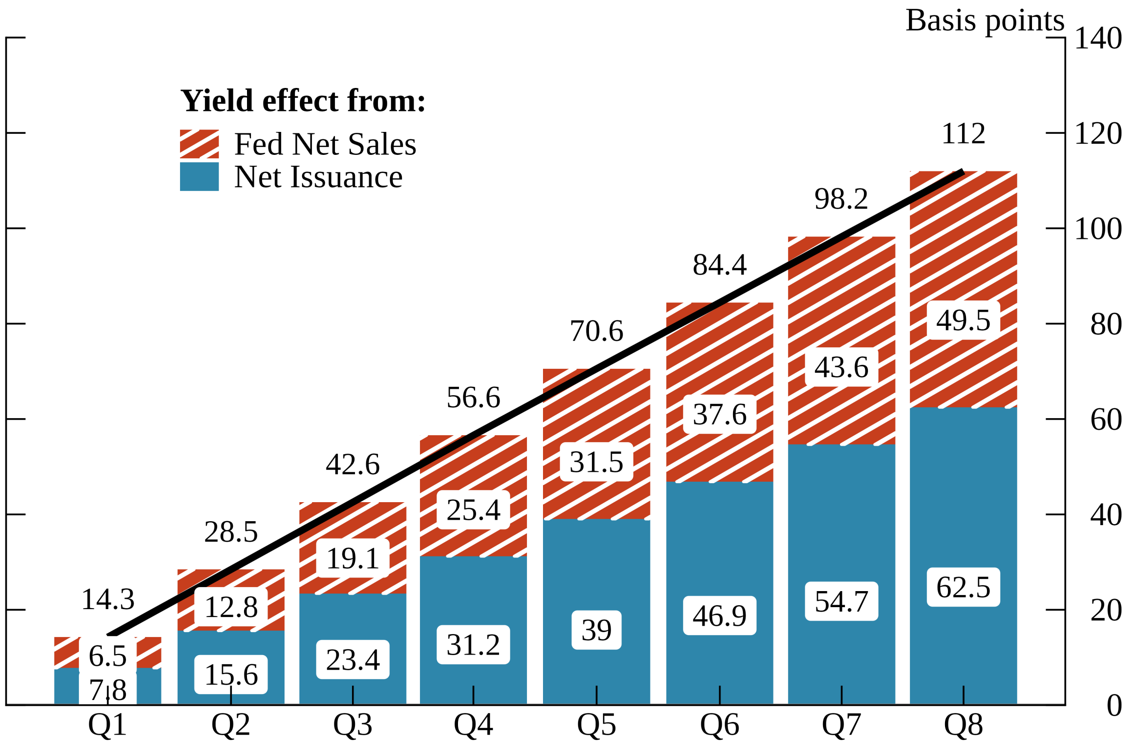


Note: Left panel shows the Federal Reserve Holdings of Treasury bonds as a percentage of GDP in a hypothetical scenario featuring a reduction of its bond holdings to 5% of GDP over 8 quarters. Right panel shows the stock of long-term Treasuries outstanding in a hypothetical scenario where GDP is expected to grow at 2.5% per year, and the stock of Treasuries grows at a rate of 5% per year.

When the Fed exits the market, it no longer absorbs new Treasury issuance and its absorption share needs to be reallocated to private sectors. We assume that the Fed's absorption share goes to zero at the start of the balance sheet runoff period, and that other sectors' absorption shares scale up proportionally. Additionally, we treat any Fed's balance sheet reductions as if they were new bond supplies that also have to be absorbed proportionally by other sectors.

Figure 9 presents the cumulative yield effects from both Fed balance sheet reduction and ongoing Treasury net issuance. The Fed balance sheet shrinkage contributes approximately 50 basis points to yield increases cumulatively over the eight quarters, while concurrent net issuance adds another 62 basis points, for a total effect of 112 basis points.

Figure 9. Yield Effects of Fed Balance Sheet Shrinkage and Net Issuance



Note: This figure shows the cumulative yield effects from both Fed sales and ongoing Treasury net issuance as implied by our model. Total does not sum up due to rounding.

These estimates highlight the magnitude of the task facing private investors in absorbing Treasuries previously held by the Fed. The yield increase of 112 basis points is economically significant and represents a non-trivial tightening of financial conditions. However, the effects are not implausibly large, suggesting that the private sector does have sufficient yield sensitivity to absorb the Fed's holdings, albeit at the cost of notably higher yields.

7 Shifting Investor Base as A Driver of Treasury Yield Movements

While our sectoral demand estimates are economically grounded, it is not obvious that they should aggregate in a way that meaningfully explains aggregate market outcomes. The elasticity estimates could be well-identified within each investor type yet fail to aggregate coherently, or maybe only the magnitude of demand shocks matters while the shocks' investor composition doesn't matter. Moreover, Treasury yields are determined by many forces—monetary policy, macroeconomic fundamentals, risk sentiment—that may dominate any signal from investor-level price sensitivities. We therefore validate our demand system estimates by testing whether the market multiplier, a proxy for investor composition, adds explanatory power for yield changes beyond standard yield curve factors and investor demand shocks. A statistically significant relationship would provide strong evidence that our demand system estimates capture genuine structural features of the Treasury market.

To quantify the yield effects from the above-discussed structural shifts in the investor base, we regress Treasury 5-year yield changes on the change in the market multiplier, while controlling for changes in standard Treasury yield factors such as changes in 1-year Treasury yield (to capture changes in monetary policy expectation) and equity returns (to capture the hedging demand on Treasuries) as well as surprise purchases by price-sensitive investors, where the surprise for each investor sector is defined as that sector's purchase in each quarter t (the flows in the Z.1 and TIC data) minus the expected purchase as measured by the net Treasury bond issuance in that quarter multiplied by the holding share estimate from our DLM for that sector in the previous quarter ($\hat{\gamma}_{i,t-1}$), and then normalized by the lagged Treasury bond outstanding held by the public (S_{t-1}).

Table 3 shows the regression results for the sample period of 2000Q2-2026Q1. As shown in the Model 1 and 2 columns, both the coefficient on the surprise investor purchases and the coefficient on the investor composition (the market multiplier) are statistically significant, suggesting that both the magnitude and the composition of the investor demand shocks matter for explaining Treasury yield movements. The coefficient estimate on the surprise purchases by all price-sensitive investors in Model 1 column suggests that a surprise purchase of 1% of Treasury bond outstanding would lower the 5-year Treasury yield by about 4 basis points. This is near the lower end of the range of the yield effect estimate per 1% of Treasury bond outstanding from our estimated demand-system model as shown in figure 6b, providing some supporting evidence to our demand-system model estimate. Furthermore,

Table 3: Treasury Yield Change Regression Analysis

	Dependent variable:		
	Change in 5-year Yield (pps)		
	Model 1	Model 2	Model 3
	(1)	(2)	(3)
Surprise purchases, all price-sensitive investors	-0.039^{***}	-0.043^{***}	
	(0.013)	(0.015)	
Surprise purchases, HHF			-0.051^{***}
			(0.012)
ΔMarket Multiplier	-18.500^{***}	-18.128^{***}	-19.297^{***}
	(5.303)	(5.178)	(4.813)
Surprise purchases $\times$ ΔMarket Multiplier		1.568	
		(1.175)	
Δ1-year Treasury yield	0.756^{***}	0.754^{***}	0.743^{***}
	(0.076)	(0.076)	(0.073)
Δ1-year Treasury yield, lagged	-0.295^{***}	-0.289^{***}	-0.286^{***}
	(0.053)	(0.056)	(0.047)
ΔLog S&P500 index	0.523^{**}	0.461^{*}	0.313
	(0.235)	(0.261)	(0.252)
ΔLog S&P500 index, lagged	0.658^{***}	0.644^{**}	0.781^{***}
	(0.243)	(0.246)	(0.251)
Observations	103	103	103
R^2	0.712	0.714	0.724
Adjusted R^2	0.694	0.693	0.707
F Statistic	39.909^{***}	34.192^{***}	42.415^{***}

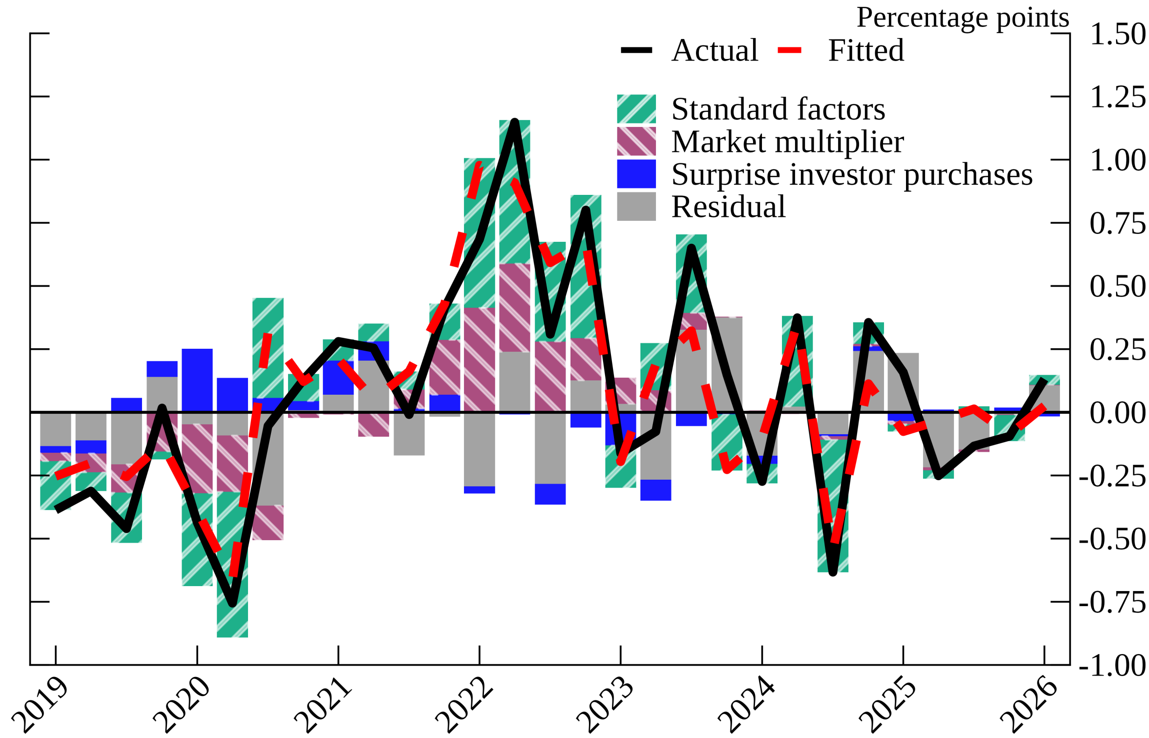
Note: All price-sensitive investors include all sectors that have positive yield elasticity estimates: HHF, BDS, ABS, ETF, MF, FPVT, PROPCAS, NFC, CEF, FOI, LIFE, and PENSION. Surprise purchases are measured in percentages of lagged Treasury bond outstanding held by the public. HAC (Newey-West, 3 lags) standard errors in parentheses. Sample period: 2000Q2-2026Q1. Significance levels: *p<0.10; **p<0.05; ***p<0.01.

Model 3 column shows that the yield effect from HHT surprise purchases is about 25% larger, consistent with our demand-system model prediction that purchases or sales by more price-sensitive investors would have larger yield effects as discussed in the policy application section above and shown in figure 8.

The negative coefficient on the change in the market multiplier (inverse of market elasticity) implies that when the market becomes more elastic, yields increase—and when less elastic, yields decline. This may seem counterintuitive: shouldn't higher elasticity mean supply shocks have smaller yield impacts? The key is understanding what causes what. A higher market elasticity translates into smaller yield effects only for supply shocks that are exogenous to changes in the market elasticity, but not for any endogenous changes in demand that, in turn, also cause the market elasticity and the market multiplier to change. If the supply shocks are allocated among the investors proportional to their past holding shares, the market elasticity and associated market multiplier will not change since we assume each sector's yield elasticity is constant over time. Therefore, the market elasticity and the market multiplier can only change for endogenous shifts in Treasury demand or exogenous shifts in Treasury supply shocks that are not allocated proportionally. For example, when market becomes more elastic, it implies that less-yield-sensitive-investors (e.g. foreign official investors) have reduced their Treasury purchases relatively, while more-yield-sensitive-investors (e.g. hedge funds) have increased their purchases relatively. If we assume that it is mainly the more-yield-sensitive-investors who price and clear the market, Treasury yield would have to increase (i.e. Treasury prices have to drop) to induce these investors to increase their purchases.

Figure 10 uses model 1 estimates to decompose the quarterly yield changes into contributions from the factors for the period since 2019Q1. While the residuals may be large in some quarters, the fit of the model overall is good as suggested by the red line closely following the black line. In particular, it shows that during the 2020 Q1-Q2 quarters (the peak of the Covid pandemic), while investor sales of Treasuries driven by liquidity needs caused Treasury yields to spike, monetary and financial factors as well as shifting investor composition help dampen the yield increase.

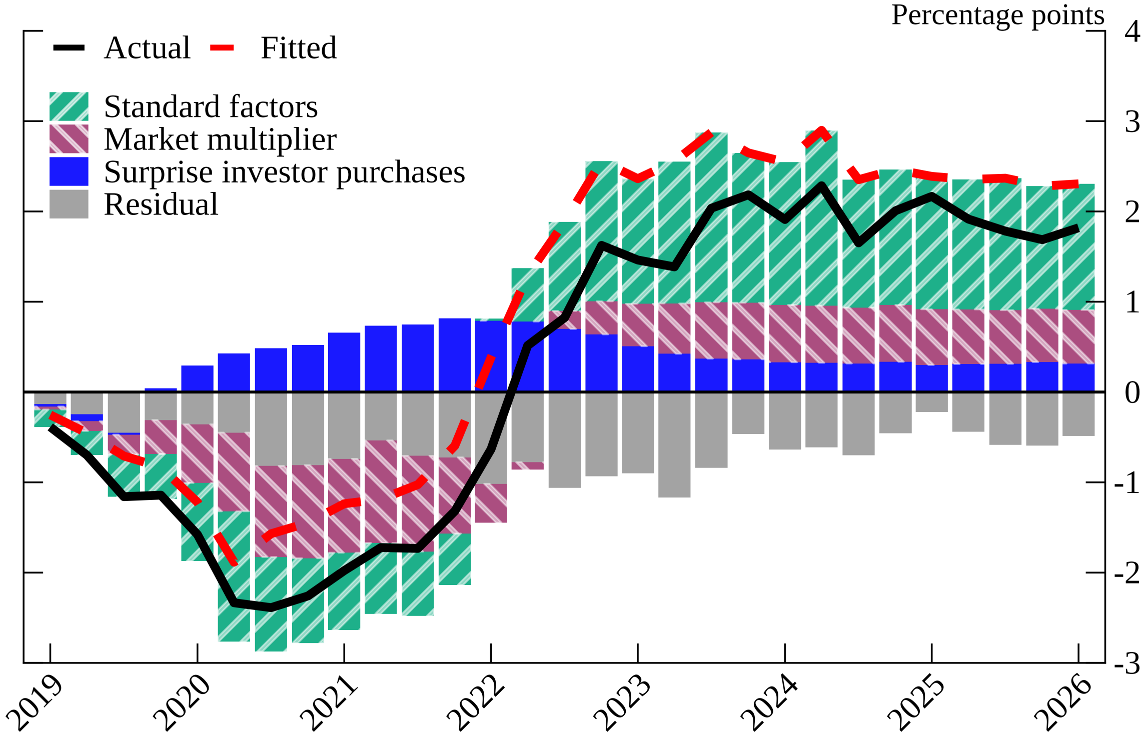
Figure 10. Decomposition of Quarterly Five-Year Yield Changes



Note: This figure shows the in-sample decomposition of quarterly yield changes over the period of 2010Q1-2026Q1 into contributions from standard yield curve factors, surprise investors purchase, and the changing investor base as proxied by the market multiplier.

As we have showed before, the increase in foreign official holdings observed during the 2000s contributed to the decline in market elasticity and thus the increase in market multiplier over this period so this finding of negative coefficient on the changing market multiplier implies that the increase in foreign official holdings could have lowered yields over this period, and similarly, the subsequent decline in foreign official holdings may have contributed to higher yields. In the meantime, after the GFC, hedge funds and and other private investors have become much more important, especially since the COVID-19 pandemic, contributing to the increase in market elasticity and the decline in market multiplier. Therefore, this shift may have also contributed to higher yields. The cumulative yield effect of these shifts since 2019Q1 is shown in Figure 11. While the (negative) surprise investor purchases have mainly contributed to the rise in Treasury yields, shifting investor base had initially offset some of the yield increase in the pandemic years of 2020-2021 and then switched to contributing positively to the the yield increase, suggesting that analyzing the shift in investor composition in the Treasury market is also important for understanding Treasury market dynamics.

Figure 11. Decomposition of Cumulative Changes in Five-Year Yield



Note: This figure decomposes the quarterly cumulative yield changes for the period of 2021Q1-2026Q1 into contributions from standard yield curve factors, surprise investor purchases, and the changing investor base as proxied by the market multiplier.

While this validation exercise establishes explanatory power, it does not establish structural validity. Reduced-form estimates linking changes in the market multiplier to yield changes could be consistent with alternative models of investor demand. So our estimates cannot, by themselves, distinguish our specific demand-system parameterization from alternative representations that would fit the data equally well (Fuchs et al., 2025). We view the exercise as a plausibility check showing that our estimated framework is not obviously inconsistent with observed yield dynamics.

8 Conclusion

We have developed a rich demand system framework for quantifying the yield effects of Treasury supply and demand changes. Our approach combines time-varying holdings shares estimated via dynamic linear models with sectoral demand elasticities estimated using instrumental variables. The framework explicitly addresses endogeneity concerns and allows for substantial heterogeneity in price sensitivity across investor types.

Our main findings can be summarized as follows. First, the Treasury market has become more price-sensitive over time, driven by the declining participation of less price-sensitive foreign official investors and the increasing role of more price-sensitive hedge funds and other private investors. Second, a $100 billion increase in Treasury supply currently raises five-year yields by approximately 3 basis points, though this effect has varied considerably over time. Third, the shifts in investor base explain a significant portion of historical yield changes.

The policy implications are significant. Our framework provides a flexible tool for scenario analysis and counterfactuals. We have illustrated applications to foreign official investor sales and Federal Reserve balance sheet reduction, finding economically significant yield effects that are broadly consistent with other approaches in the literature. The framework can be readily applied to other scenarios of interest to policymakers.

An important insight from our analysis is the fragility risk associated with the rising role of highly elastic investors. In normal times, these investors dampen yield responses to shocks by adjusting their portfolios. However, when they step back from the market during stress periods such as March 2020, price sensitivity collapses and yield volatility can increase sharply. Understanding these dynamics is crucial for both monetary policy and financial stability analysis.

Several directions for future research emerge from our work. First, extending the model to include equities and other asset classes would provide a more complete picture of portfolio allocation decisions and cross-asset spillovers. Second, incorporating time-varying elasticities more systematically into the counterfactual analysis could capture regime shifts in investor behavior. Third, exploring the microstructure of how price-sensitive investors such as hedge funds transmit shocks—through leverage, funding liquidity, and intermediation capacity—would deepen our understanding of fragility risks. Finally, combining our demand-side approach with supply factors such as debt maturity management and fiscal projections could provide a comprehensive framework for debt management policy.

The Treasury market plays a central role in the financial system and the transmission of monetary policy. Understanding how supply and demand forces interact to determine yields is essential for both policymakers and market participants. Our demand system framework provides a empirically grounded approach to these questions, with applications ranging from Federal Reserve balance sheet policies to fiscal sustainability. As the Treasury market continues to evolve, particularly with the growth of nonbank financial intermediation, approaches such as ours will remain valuable for assessing market dynamics and policy options.

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Appendix A: Estimation of Time-varying Holdings Shares

This appendix describes the Bayesian Dynamic Linear Model (DLM) used to estimate time-varying sectoral holdings shares of U.S. Treasury securities. The model simultaneously estimates the holdings shares of Treasury notes and bonds (long-term securities) and Treasury bills (short-term securities) across 18 investor sectors, subject to the constraint that the shares sum to one at each point in time.

Model Structure

The model follows the general state-space form described in Petris et al. (2009):

$$\mathbf{z}_t = \mathbf{F}_t \boldsymbol{\theta}_t + \boldsymbol{\nu}_t, \quad \boldsymbol{\nu}_t \sim N(\mathbf{0}, \mathbf{V}) \tag{14}$$

$$\boldsymbol{\theta}_t = \mathbf{G} \boldsymbol{\theta}_{t-1} + \boldsymbol{\omega}_t, \quad \boldsymbol{\omega}_t \sim N(\mathbf{0}, \mathbf{W}) \tag{15}$$

where $\mathbf{z}_t$ is the vector of observable variables at time t, $\boldsymbol{\theta}_t$ is the unobserved state vector containing the bond and bills holdings shares. $\mathbf{F}_t$ is the observation matrix, which is time varying as it includes the explanatory variables used to estimate the holdings shares for each sector at each point in time: Treasury bonds outstanding at market value, and Treasury bills outstanding at market value. $\mathbf{G}$ is the state evolution matrix, $\mathbf{V}$ is the observation error covariance matrix, and $\mathbf{W}$ is the state innovation covariance matrix.

Observable Variables

The observable vector $\mathbf{z}_t$ consists of 25 elements:

$$\mathbf{z}_t = \begin{bmatrix} H_{1t} & H_{2t} & \cdots & H_{23t} & S_t^{\text{bonds}} & S_t^{\text{bills}} \end{bmatrix}' \tag{16}$$

where: H_{it} for $i = 1, \ldots, 23$ denotes a given measure of Treasury holdings for a given sector, which will be either:

- their total holdings of Treasury bills, notes, and bonds, in millions of dollars, or,
- their holdings of just long-term Treasuries (notes and bonds), in millions of dollars, or,
- their holdings of just short-term Treasury (bills only), in millions of dollars.

We make several assumptions to reduce the number of state variables, simplify the data, and facilitate the estimation:

- We assume that money market funds only hold Treasury bills. That is, we assume they hold no bonds so we do not estimate their bond share. We treat their bond holdings reported in the Z.1 tables as if they were bills holdings.
- We assume that the household and hedge funds sector only holds bonds, so we do not estimate their bill share. This assumption is supported by findings of Tabova and Warnock (2026) that shows that private investors prefer longer duration securities, and by the fact that the substantial holdings of Treasuries by hedge funds involved in the Treasury cash-futures basis trade are Treasury notes and bonds, not bills (Barth and Kahn, 2025). Also, when constructing the HHF sector, we exclude the bill holdings from TIC for Ireland, Luxembourg, and Caribbean tax havens.
- We assume assume life insurers only hold bonds, so we do not estimate their bills share. Their bill holdings, reported separately, are small and comprise only 10 percent of their total Treasury holdings, so we ignore them. We adjust their holdings data by converting their bill holdings to bond holdings.

With these data adjustments, our holdings data (H_{it} for $i = 1, \ldots, 23$) in $\mathbf{z}_t$ is:

1. Household and hedge funds holdings of Treasury bonds

2. ABS holdings of all Treasuries
3. ETF holdings of all Treasuries
4. Mutual fund holdings of all Treasuries
5. Foreign private holdings of Treasury bonds
6. Foreign private holdings of Treasury bills
7. Property and casualty insurers holdings of Treasury bonds
8. Property and casualty insurers holdings of Treasury bills
9. Nonfinancial business holdings of all Treasuries
10. Closed-end funds holdings of all Treasuries
11. Foreign official holdings of Treasury bonds
12. Foreign official holdings of Treasury bills
13. Life insurers holdings of Treasury bonds
14. Life insurers holdigs of Treasury bills
15. Pension fund holdings of all Treasuries
16. Other financial holdings of all Treasuries
17. Bank holdings of all Treasuries
18. State and local governments holdings of all Treasuries
19. Government-sponsored enterprises holdings of all Treasuries
20. Money market fund holdings of Treasury bills
21. Broker dealers holdings of all Treasuries
22. Federal Reserve holdings of Treasury bonds
23. Federal Reserve holdings of Treasury bills

The last two observables in $\mathbf{y}_t$ are vectors of ones, ensuring that the sum of bond shares ($\gamma_{it}^{\text{bond}}$) and the bills shares ($\gamma_{jt}^{\text{bill}}$) sum to unity at each point in time:

$$\sum_{i=1}^{17} \gamma_{it}^{\text{bond}} = 1 \tag{17}$$

$$\sum_{j=1}^{16} \gamma_{jt}^{\text{bill}} = 1 \tag{18}$$

.

We set the observation errors for these equations to very small values (effectively zero) to strongly enforce the constraint.

State Variables

The state vector $\boldsymbol{\theta}_t$ contains 33 elements representing the latent holdings shares:

$$\boldsymbol{\theta}_t = \begin{bmatrix} \gamma_{1t}^{\text{bond}} & \gamma_{2t}^{\text{bond}} & \cdots & \gamma_{17t}^{\text{bond}} & \gamma_{1t}^{\text{bill}} & \gamma_{2t}^{\text{bill}} & \cdots & \gamma_{16t}^{\text{bill}} \end{bmatrix}' \tag{19}$$

where:

- $\gamma_{it}^{\text{bond}}$ is the latent holdings share for sector i holding bonds ($i = 1, \ldots, 17$), representing the fraction of total bonds outstanding held by sector i. There are 17 bond holdings share parameters because MMFs are assumed to only hold bills.

- $\gamma_{jt}^{\text{bill}}$ is the latent holdings share for sector j holding bills ($j = 1, \ldots, 16$), representing the fraction of total bills outstanding held by sector j. There are 16 bills holdings share parameters because HHF and life insurers are assumed to only hold bonds

Observation Matrix $\mathbf{F}_t$

The observation matrix $\mathbf{F}_t \in \mathbb{R}^{25\times 33}$ maps the state vector (holdings shares) to the observable variables (dollar holdings). The matrix contains the amounts of bonds and bills outstanding at time t, which makes it time-varying.

The structure of $\mathbf{F}_t$ is constructed using the `dlmModReg()` function in R, which takes the matrix of regressors $\mathbf{X}_t$ containing bonds outstanding and bills outstanding for each observation equation. Specifically:

For rows that map to bond holdings only (rows 1,4,5,7,11,13,22): The corresponding row of $\mathbf{F}_t$ has $\text{Bonds\_outstanding}_t$ in the column corresponding to that sector's bond share state variable, and zeros elsewhere.

For rows that map to bill holdings only (rows 6,8,12,14,20,23): The row has $\text{Bills\_outstanding}_t$ in the column corresponding to sector's bill share state variable.

For rows that map to total Treasury holdings (rows 2,3,9,10,15,16,17,18,19,21): The row has $\text{Bonds\_outstanding}_t$ in the bond share column and $\text{Bills\_outstanding}_t$ in the bill share column for that sector.

For constraint equations (rows 24,25): Row 24 has ones in all columns corresponding to bond share state variables (columns 1–17) and zeros elsewhere. Row 25 has ones in all columns corresponding to bill share state variables (columns 18–33) and zeros elsewhere.

The constraint rows are:

$$\mathbf{F}_{t,24\cdot} = \begin{bmatrix} 1 & 1 & \cdots & 1 & 0 & 0 & \cdots & 0 \end{bmatrix} \quad \text{(17 ones, 16 zeros)} \tag{20}$$

$$\mathbf{F}_{t,25\cdot} = \begin{bmatrix} 0 & 0 & \cdots & 0 & 1 & 1 & \cdots & 1 \end{bmatrix} \quad \text{(17 zeros, 16 ones)} \tag{21}$$

State Evolution Matrix G

The state evolution follows a random walk:

$$\mathbf{G} = \mathbf{I}_{33} \tag{22}$$

This implies that holding shares evolve smoothly over time without any deterministic trend:

$$\gamma_{it}^{\text{bond}} = \gamma_{i,t-1}^{\text{bond}} + \omega_{it}^{\text{bond}}, \quad \omega_{it}^{\text{bond}} \sim N(0, \sigma_{\omega,i}^2) \tag{23}$$

$$\gamma_{it}^{\text{bill}} = \gamma_{i,t-1}^{\text{bill}} + \omega_{it}^{\text{bill}}, \quad \omega_{it}^{\text{bill}} \sim N(0, \sigma_{\omega,i}^2) \tag{24}$$

The random walk specification is appropriate for holding shares that adjust gradually in response to changes in the economic environment and investor preferences.

Covariance Matrices

Observation Error Covariance V

The observation error covariance matrix $\mathbf{V} \in \mathbb{R}^{25\times 25}$ is assumed to be diagonal:

$$\mathbf{V} = \text{diag}(\sigma^2_{v,1}, \sigma^2_{v,2}, \ldots, \sigma^2_{v,23}, \epsilon^2, \epsilon^2) \tag{25}$$

where $\sigma^2_{v,i}$ are the observation error variances for each holdings equation (capturing measurement error and model misspecification), and $\epsilon^2 \approx 0$ are the very small variances for the constraint equations (rows 24–25).

The diagonal structure assumes that measurement errors across sectors are uncorrelated, conditional on the state. This is a standard simplification in high-dimensional DLMs.

State Innovation Covariance W

The state innovation covariance matrix $\mathbf{W} \in \mathbb{R}^{33\times 33}$ is also diagonal:

$$\mathbf{W} = \text{diag}(\sigma^2_{\omega,1}, \sigma^2_{\omega,2}, \ldots, \sigma^2_{\omega,33}) \tag{26}$$

The variance parameters $\sigma^2_{\omega,i}$ control the smoothness of the estimated holding shares over time. Smaller values produce smoother trajectories, reflecting the fact that sectoral portfolio shares evolve gradually rather than jumping erratically from quarter to quarter.

Table 4 summarizes the model dimensions.

Table 4: Model Dimensions

Component	Dimension
Observable variables ($\mathbf{z}_t$)	25
Dollar holdings (bonds + bills)	23
Constraint equations	2
State variables ($\boldsymbol{\theta}_t$)	33
Bond holding shares	17
Bill holding shares	16
Observation matrix ($\mathbf{F}_t$)	25×33
State evolution matrix ($\mathbf{G}$)	33×33
Observation covariance ($\mathbf{V}$)	25×25
State innovation covariance ($\mathbf{W}$)	33×33
Variance parameters (calibrated)	58
Observation variances	25
State innovation variances	33

Prior Specification

Initial State Distribution

The initial state $\boldsymbol{\theta}_0$ (the holding shares at time $t = 0$) follows a normal prior distribution:

$$\boldsymbol{\theta}_0 \sim N(\mathbf{m}_0, \mathbf{C}_0) \tag{27}$$

Prior Mean $\mathbf{m}_0$

The prior mean is estimated using ordinary least squares (OLS) regressions of each sector's total holdings on the Treasury bills and bonds outstanding for these sectors that don't report bills versus bonds holdings separately, or their bill holdings on the bills outstanding and their bond holdings on bonds outstanding if they do report them separately, over the full sample without an intercept.[12] We then normalized estimates so they sum to one for bills and bonds, respectively.

[12]For HHF and life insurers, because we assume they only hold bonds, we run only the bond regression, and for MMF, because we assume they only hold bills, we run only the bill regression.

The prior covariance matrix is diagonal:

$$\mathbf{C}_0 = \mathrm{diag}(\sigma^2_{m_0,1}, \sigma^2_{m_0,2}, \ldots, \sigma^2_{m_0,33}) \tag{28}$$

where $\sigma^2_{m_0,i}$ are the squared standard errors from the OLS regressions used to construct $\mathbf{m}_0$. This reflects our uncertainty about the initial holding shares.

Observation error variances

While the variance parameters $\{\sigma^2_{v,i}, \sigma^2_{\omega,j}\}$ could be estimated using maximum likelihood estimation (MLE), MLE tends to select large state innovation variances $\sigma^2_{\omega,j}$ to fit short-run fluctuations in the holdings data. This produces holding shares that are too volatile, changing rapidly from quarter to quarter in ways that seem implausible given the institutional structure of Treasury markets. Instead, we calibrate the variance parameters to ensure that estimated holding shares evolve smoothly and satisfy the constraints tightly.

The observation errors $\sigma^2_{v,i}$ capture the inherent measurement error in the holdings data as well as model misspecification. Using a scaling factor, we set the observation error variances in proportion to the observed variances. That is, for y_{it} for $i = 1, \ldots, 23$

$$\sigma^2_{v,i} = \widehat{\mathrm{Var}}(y_{it}) * scaling\_factor, \tag{29}$$

where the scaling factor is set to 0.02 (one fiftieth of the observed variance).

We enforce the constraint equations (rows 24–25) tightly:

$$\sigma^2_{v,24} = \sigma^2_{v,25} = 0. \tag{30}$$

The state innovation variances $\sigma^2_{\omega,i}$ are set to small values to capture the gradual secular trends in the holding shares. After some experimentation, and based on visual inspection of the estimated paths for the holdings shares, we set $\sigma^2_{\omega,j} = exp(-24)$

By calibrating the state innovation variances to be small, we effectively impose a prior belief that holdings shares are persistent. This calibration approach prioritizes economic interpretability and plausibility over pure statistical fit, which is appropriate given our goal of measuring structural holdings shares rather than fitting short-run fluctuations.

Kalman Filter

The Kalman filter provides optimal estimates of the state $\boldsymbol{\theta}_t$ (the holding shares) given observations up to time t. After writing the model in state-space form, we estimate the posterior distributions of the holdings shares recursively forward in time using the Kalman Filter, starting with an informative prior at $t = 0$. Because we are interested in retrospective inspection of the state variables using the full sample period, we use a backward recursive (smoothing) algorithm to compute the conditional distributions of $\boldsymbol{\theta}_t$ for any $t < T$ given the observations $\boldsymbol{z}_{1:T}$, starting from the filtering distribution $\pi(\boldsymbol{\theta}_T|\boldsymbol{z}_{1:T})$. We ignore the estimated posterior means during the first 4 years of our sample to allow the Kalman filter to converge. We use the smoothed estimates as our final time-varying holdings shares for all results reported in the paper.

Appendix B: Estimation of Sectoral Treasury Demand Elasticities: Full Set of Controls and Cross-validated LASSO Selected Controls

This appendix describes two additional instrumental-variables (IV) approaches for estimating sectoral demand elasticities. The two approaches share an identical estimating equation, instrument, and inference procedure; they differ only in how the set of macro-financial control variables is chosen. The first approach includes the full set of seven controls in every sector's equation. The second approach uses *cross-validated LASSO* (CV-LASSO) to select sector-specific subset of controls by an objective, data-driven rule.

Common estimating framework

For each investor sector i we estimate the demand equation

$$s_{i,t} = \alpha_i + \beta_i \cdot \hat{y}_t + \lambda_i \cdot s_{i,t-1} + \mathbf{X}_t' \boldsymbol{\delta}_i + \epsilon_{i,t} \tag{31}$$

where $s_{i,t}$ is the log of sector i's Treasury portfolio share, y_t is the five-year Treasury yield, and X_t is a vector of macro-financial controls drawn from a common candidate pool of seven variables:

Code	Variable
$X1$	log broad nominal U.S. dollar index
$X2$	log VIX
$X3$	U.S. corporate profit rate
$X4$	TED spread
$X5$	Brent crude oil futures price
$X6$	log S&P 500 index
$X7$	CPI inflation

Given the controls, β_i is estimated by two-stage least squares with the instrument of (Fed + GSEs + State and Local Governments+ Other)/Treasury bond market size.

Approach 1: Full controls

The full controls specification includes all seven candidate controls $X1$–$X7$ in every sector's demand equation, alongside the lagged dependent variable. This is a single, pre-specified specification applied uniformly across sectors: no selection or search over controls is performed, so there is no risk of selection-induced distortion to the reported inference. Its cost is parsimony—at $n = 51$, spending seven degrees of freedom on controls in every equation is demanding—but it provides a transparent, common benchmark against which the data-driven approach can be judged.

Compared to the main text results with sector-specific controls, the full controls specification generally yields similar magnitudes but somewhat weaker statistical significance, reflecting the trade-off between parsimony and fit.

Table 5: Treasury demand elasticities (full set of controls): all sectors

Sector	$\hat{\beta}$	HAC t	1st-st. F	Wu-Hausman	Wu-Hausman p
HHs & hedge funds	36.53**	2.54	8.6	11.56	0.002
Households	23.90**	2.03	38.3	14.11	0.001
Hedge funds	7.58**	2.69	38.0	9.75	0.003
Inv. funds (Lux.)	4.06	0.92	12.3	5.12	0.029
Inv. funds (Ireland)	2.16	0.29	9.5	0.77	0.386
ABS issuers	14.82**	2.62	16.8	3.33	0.075
ETFs	10.22**	2.37	26.4	5.91	0.020
Mutual funds	6.71*	1.94	33.8	3.76	0.060
Foreign private	8.37	1.66	10.2	4.63	0.037
Prop. & casualty	7.44***	3.02	30.0	8.77	0.005
Nonfinancial bus.	0.35	0.07	15.4	0.17	0.680
Closed-end funds	1.30	0.43	16.3	0.56	0.460
Foreign official	1.06	1.61	15.3	0.16	0.688
Life insurance	2.05	1.08	13.8	1.07	0.307
Pension funds	1.95	1.50	36.5	0.69	0.412
Banks & bank HCs	2.28	0.66	22.9	0.12	0.731
Broker-dealers	3.68	0.19	11.7	1.27	0.266

Sample 2009:Q1–2022:Q1 excluding 2020:Q1 ($n = 51$). The dependent variable is the log of a sector's Treasury portfolio share; $\hat{\beta}$ is the semi-elasticity with respect to the 5-year Treasury yield, instrumented by official-sector Treasury absorption (Instrument: (Fed + GSEs + State and Local Governments + Other)/Treasury bond market value).
Controls: The full set of seven macro-financial demand shifters (log broad dollar, log VIX, corporate profit rate, TED spread, Brent oil price, log SP500 index, CPI inflation) is included in every sector's demand equation, together with the lagged dependent variable.
HAC (Newey–West, lag 3) standard errors; t is the HAC t-statistic on $\hat{\beta}$. F is the first-stage (weak-instrument) statistic. Wu–Hausman is the test statistic (and its p-value) for the endogeneity of the yield. Stars on $\hat{\beta}$ denote significance on the HAC p-value: $^{*}\,p < 0.10$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$.

Approach 2: Cross-validated LASSO (CV-LASSO)

The CV-LASSO approach lets the data choose a sector-specific control set while keeping the selection rule orthogonal to the significance of β_i. For each sector we run three LASSO regressions over the seven candidate controls—one for the outcome $s_{i,t}$, one for the endogenous yield y_t, and one for the instrument—always forcing in the lagged dependent variable (its coefficient is left unpenalized). In each LASSO the penalty is chosen by five-fold cross-validation (the largest penalty within one standard error of the cross-validation minimum, which favors parsimony). The control set used in estimation is the *union* of the variables selected in any of the three equations. Taking the union guards against dropping a control that matters through the outcome, the treatment, or the instrument channel. Crucially, none of the three selection steps looks at β_i or its significance, so the subsequent HAC inference on $\hat{\beta}$ remains valid.

Selection is heterogeneous but economically coherent. The corporate profit rate ($X3$) and VIX ($X2$) are selected for every sector, and the log SP500 index ($X6$) for nearly every sector (all but closed-end funds and broker-dealers), consistent with these being the most broadly relevant demand shifters. The dollar ($X1$), TED spread ($X4$), oil price ($X5$), and CPI inflation ($X7$) are chosen more rigorously. Hedge funds, nonfinancial business, investment funds (Ireland), ETFs, foreign private, pension funds, banks, and broker-dealers retain six or seven controls, while closed-end funds and ABS issuers use only two or three. This cross-sector heterogeneity is obtained by a disciplined rule rather than by searching over the elasticity's significance.

The elasticities are broadly stable relative to the specification with full controls, which is reassuring given the very different control counts. For some sectors (hedge funds, ETFs), the CV-LASSO estimates are identical to the full controls specification because LASSO selected all seven controls.

Table 6: Treasury demand elasticities (CV-LASSO): all sectors

Sector	$\hat{\beta}$	HAC t	1st-st. F	Wu-Hausman	WH p	Selected controls
HHs & hedge funds	40.93**	2.47	8.8	15.30	0.000	X2, X3, X4, X6
Households	29.22**	2.61	51.3	19.37	0.000	X2, X3, X4, X6
Hedge funds	7.58**	2.69	38.0	9.75	0.003	X1, X2, X3, X4, X5, X6, X7
Inv. funds (Lux.)	5.58	1.35	17.2	6.07	0.018	X2, X3, X4, X5, X6
Inv. funds (Ireland)	2.16	0.29	9.5	0.77	0.386	X1, X2, X3, X4, X5, X6, X7
ABS issuers	13.81***	3.00	19.6	2.88	0.097	X2, X3, X6
ETFs	10.22**	2.37	26.4	5.91	0.020	X1, X2, X3, X4, X5, X6, X7
Mutual funds	7.48**	2.09	42.3	2.93	0.094	X2, X3, X6
Foreign private	8.03*	1.77	11.3	4.75	0.035	X1, X2, X3, X5, X6, X7
Prop. & casualty	7.61***	3.17	32.2	6.85	0.012	X2, X3, X4, X6
Nonfinancial bus.	0.35	0.07	15.4	0.17	0.680	X1, X2, X3, X4, X5, X6, X7
Closed-end funds	4.98	1.42	19.3	0.10	0.748	X2, X3
Foreign official	1.17**	2.16	17.5	0.23	0.636	X1, X2, X3, X5, X6, X7
Life insurance	0.51	0.27	18.3	0.04	0.851	X2, X3, X4, X5, X6
Pension funds	1.85	1.44	37.7	0.62	0.436	X1, X2, X3, X4, X5, X6
Banks & bank HCs	2.49	0.68	21.2	0.18	0.675	X1, X2, X3, X4, X5, X6
Broker-dealers	-3.74	-0.22	13.8	0.98	0.328	X1, X2, X3, X5, X6, X7

Sample 2009:Q1–2022:Q1 excluding 2020:Q1 ($n = 51$). The dependent variable is the log of a sector's Treasury portfolio share; $\hat{\beta}$ is the semi-elasticity with respect to the 5-year Treasury yield, instrumented by official-sector Treasury absorption (Instrument: (Fed + GSEs + State and Local Governments + Other)/bond market value).

Controls: for each sector the control set is selected by a cross-validated LASSO (5-fold, λ_{1se}), taking the union of controls chosen in the outcome, treatment (yield), and instrument equations. The lagged dependent variable is always retained (unpenalized). Selection never uses the significance of $\hat{\beta}$. The 'Selected controls' column lists the chosen variables, coded $X1$–$X7$: $X1$ = log broad nominal U.S. dollar index, $X2$ = log VIX, $X3$ = U.S. corporate profit rate, $X4$ = TED spread, $X5$ = Brent crude oil futures price, $X6$ = log SP500 index, $X7$ = CPI inflation.

HAC (Newey–West, lag 3) standard errors; t is the HAC t-statistic on $\hat{\beta}$. F is the first-stage (weak-instrument) statistic. Wu–Hausman is the test statistic (and its p-value) for the endogeneity of the yield. Stars on $\hat{\beta}$ denote significance on the HAC p-value: $^{*}\,p < 0.10$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$.